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Coastal changes and land use alteration on Northeastern part of Turkey

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ABSTRACT

Coasts, not only today but throughout history, have been valuable, important and attractive areas for mankind. Unfortunately, the link between coasts and user has not been stayed in balance due to growing pressure from increasingly diverse human activities. Anthropogenic pressure on coastal areas is rising because of the fact that people are tend to settle by the coast for some reasons such as better transportation, nutrition and commerce. Many conflicts were observed during the establishment of mega cities on coastal zones. Unfortunately, sustainability is generally neglected through the solution process of the coastal problems. Even though, it is a relatively late step, the recent initiatives have a potential to decrease the anthropogenic pressure on coastal zones in Turkey. To achieve the best management strategy, there should be a well established connection between science and policy. Therefore novel technologies should be used for better monitoring and mapping the coastal zones. Coastline mapping is one of the fundamental steps of Integrated Coastal Zone Management (ICZM) planning. In this study, coastal zone of the Trabzon city which comprises approximately 110 km length including central district and 9 coastal counties was investigated in terms of decadal coastline changes and associated land use/cover (LULC) types. Automatic extraction of the coastline was achieved by applying proposed methodology on multispectral Landsat TM/ETM images. To obtain the LULC classes, Support Vector Machine (SVM) algorithm was implemented and four classes, water, vegetation, impervious surface and bare soil were identified. Finally all graphical data was transferred and analyzed within GIS environment. The coastline changes were evaluated by using a GIS tool of Digital Shoreline Analysis System (DSAS). DSAS results revealed that, the net coastline change was reached up to 88.2 m in central region of Trabzon. It was found that during the time span (1984–2011) coastal agricultural lands were intentionally converted to impervious surfaces. The ratio analyses of the study area showed that impervious surface area was doubled for the last 27 years. The coastal zone of the region can be characterized with “accretion” type zone. The geomorphologic character, linear-littoral development of the city and recently completed North Anatolian highway might be dominant effects in shaping the coastal zone character. In conclusion, decadal change analyses prove that the coastal zone of the city is under severe anthropogenic effects as it can be observed in some other coasts of Turkey.

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1. Introduction

Urbanization problem is one of the major challenges of the today's world. The rate of unplanned and fast urbanization is increasing as the migration trend heads toward mega cities. Significant part of emerging migration has been directed to the coastal cities for better and comfortable living standards. However, the catastrophic impacts of global climate change phenomena are becoming more sensible in coastal regions. Therefore, anthropogenic pressure on those areas can only be mitigated by a proper coastal management strategy (Barbiere, 1999). The main reason of anthropogenic pressure on coastal zone is mainly because of the fact that these areas are connection interfaces between marine and terrestrial activities (Cao and Wong, 2007). While coastal zones only cover almost 10% of total earth surfaces, they provide space for approximately 50% of the world population (Shi et al., 2001). Moreover, 80% of mega cities are located along the coastal periphery of the mainland (Baird, 2009). Similar to other coastal countries, Turkey has been experiencing some problems and conflicts, stemmed from intense and unplanned usage of coastal zone, related to coastal planning (Masalu, 2000). Population

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density, urban sprawl, sectorial conflicts, pollution, natural resource depletion, coastline changes, and land use/cover alterations are some of the main problems (Fabbri, 1998; Cao and Wong, 2007). However, very high demand and increasing pressure for coastal areas can sometimes create unforeseen results. For instance, coastal land use alteration can lead coastal zone to be more vulnerable to external effects. Urbanization is increasing in very fast and unplanned manner in Turkish coastal zone as it is in some other parts of the world. The increasing rate of impervious surface ratio was reported in studies on land alteration (Alphan, 2003). Landscape fragmentation is also an indirect result of land alteration activities which break off the ecological connectivity in coastal zone (Guneroglu et al., 2013b). Additionally, changing natural land cover with artificial surfaces may also deteriorate the coastal marine ecosystem (Bulleri and Chapman, 2010). This can be observed as changing interactions between flora and fauna as well as the quality of surface run off, sediment structure, and anthropogenic pollution on littoral zone. Therefore, studying temporal coastline changes and coastal land use are important research areas in terms of ICZM planning (Sesli et al., 2009). This is because sustainability of coastal zones depends on the continuity of the healthy ecosystem services. Changes in land use/cover structure may interrupt the quality of those services.

The most important two processes that determine coastal morphology are erosion and accretion dynamics. Erosion and accretion can occur as a result of human induced or natural causes. Erosion and accretion in some cases may occur at the same time or one after another as it is observed in Adapazarı-Karasu case (Gormus et al., 2014). Coastal erosion is still one of the biggest threats for coastal zones in Turkey as it is in some other regions of the world seas, thus it is always a popular research topic of the coastal engineering community (Kuleli et al., 2011; Thi et al., 2014). Therefore temporal monitoring coastal morphology can help to minimize the vulnerability of the coastal zone against unwanted external challenges.

There are novel technologies for continuous monitoring of the coastline change that is one of the well-known geographic indicators in literature. Recently, in addition to the traditional surveying techniques remote sensing technologies are widely used to get quantitative and qualitative information on coastal morphological changes (Sesli et al., 2009; Kuleli et al., 2011). Remote sensing and Geographic Information System (GIS) technologies are offering fast, cheap and robust solutions in detecting coastline changes when compared to the traditional techniques. Furthermore, environmental quality indicators such as LULC changes, urbanization, deforestation and fragmentation are also monitored by remote sensing techniques (Ulbricht and Hackendorf, 1998). Availability and ease of access to multispectral remotely sensed data have greatly facilitated the monitoring of environmental processes such as coastline change, LULC change and coastal hydrologic processes (Dihkan et al., 2011; Karsli et al., 2011; Guneroglu et al., 2013a). Instead of using classical surveying techniques, GIS and RS techniques are more trustworthy in obtaining reliable data regarding coastline changes (Muslim et al., 2006; Appeaning Addo et al., 2008). Recent information on occurrence probability of global climate change scenarios has stressed evaluating the coastline processes with caution as different scenarios suggesting various sea level changes for different geographic locations (Kuleli et al., 2009; Allenbach et al., 2015). In some climate projections it is estimated that if the current situation continuous there would be sea level changes up to 7 m and approximately 70% of total coastal zones might be effected (IPCC AR5, 2014). Therefore, monitoring of coastline changes can diminish the potential risks factor for management of the coastal zones. Even though it is accepted as a linear geographic feature, coastline has a very dynamic nature and it is prone to natural and anthropogenic affects (Karsli et al., 2011). Factors governing coastal changes would be various such as hydrologic, climatologic, and anthropogenic (Anker et al., 2004). Meanwhile, measuring the coastline without bias is very difficult under the influence of tidal oscillation, sediment dynamics and hydrologic processes. But, the need for coastline changes data requires neglecting some measurement uncertainties from the beginning (Appeaning Addo et al., 2008; Allenbach et al., 2015).

Turkish Republic is a peninsula surrounded by 3 marginal seas. The coastal zone of the country is about 8333 km long and covers 4 different geographic regions with more than hundreds thousands km squares. The coastal settlement areas totally inhabit more than twenty five million populations (Kuleli et al., 2009). The coastal cities have vital importance in terms of national economical aspects. The Istanbul city itself is an international logistic center where many national and international commercial activities take place in. This mega city is responsible for one fourth of national economical budget and more than half of national import-export volume (Dogan, 2013). It is evident that if other coastal cities such as Kocaeli, Izmir, Mersin, Adana and Bursa are considered regarding total national budget, it will be found that the majority of national economic operations occur on coastal zone of Turkey. Therefore, it is a necessity to monitor the coastal areas by considering environmental as well as economical aspects. Similar problems that can be observed in some other coastal regions of Turkey are also available in Northeastern coastal zone (Ekercin, 2007; Bayram et al., 2008; Kurt, 2013). Accretion and unplanned urbanization are such problems in Trabzon city where they caused coastline changes and increased the rate of impervious surfaces (Sesli et al., 2009). Moreover, small scale industrialization, unplanned development and solid waste management are some other stressors of coastal zone in Trabzon city and its close vicinity (Guneroglu, 2010). Even though it has no pronounced economical specialty, Trabzon city is important in terms of tourism potential, seaport and strategic location which are major drivers for protecting the coastal zone of this unique historical city. Coastal landscape of the Trabzon city is also under negative impacts of coastal engineering structures, breakwaters, groins and fishing wharfs. It is known that today's coastal zone areas of Trabzon city and coastal counties were previously used as agricultural fields. Thus, there is a need to investigate the land alteration process historically occurred in the region in order to achieve sustainable development of the city. In this study, the coastal zone of Trabzon city including central district and 9 coastal counties were quantitatively investigated in terms of coastal LULC changes and coastline dynamics for the period of 1984–2011.

2. Study area and data

Coastal land use alteration and coastline changes from 1984 to 2011 were investigated along the Trabzon city coast including central district and nine coastal counties that totally comprises 110 km long coastline. The study area has been generally used to supply services such as beach, port facilities, fisherman wharfs, residential and transportation. In order to strength the coastal stabilization, breakwaters, jetties and groins were observed from place to place as coastal engineering structures in the region. Detailed map showing the study area is presented in Fig. 1.

The Landsat system has been popular in remote sensing applications for coastal changes and other environment related studies (Tucker et al., 2004) due to relatively high ground resolution and availability of continuous data supply. Moreover, multispectral capabilities of MSS, TM and ETM + sensors have widen application areas of the remotely sensed data. Geo-referenced Landsat TM and

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